CLAIMS

What is claimed is:

1.   A method of separating first and second mixture signals received through two

sensors into source signals, comprising:

(a) calculating a global signal absence probability for each frame of the mixture signals

and a local signal absence probability for each frequency band of a frame for at least one of the

first and second mixture signals;

(b) estimating a spectrum vector in which a noise signal is eliminated for each frequency

band using the global signal absence probability calculated in the calculating;

(c) determining a plurality of frequency bands including at least one of a noise signal and

a source signal using the local signal absence probability, and generating a source label vector

which consists of a plurality of frequency bands assigned to each source, using an attenuation

parameter and a delay parameter generated for each of the determined frequency bands; and

(d) multiplying the spectrum vector estimated for each frequency band obtained in the

estimating by the source label vector obtained in the determining, and obtaining signals

separated according to the source signals.

2.   The method of claim 1, wherein the calculating comprises:

(a1) generating likelihood ratios for each of the frequency bands of a specified frame;

(a2) multiplying the likelihood ratios by a priori probabilities, respectively;

(a3) adding a specified value to the respective multiplied results;

(a4) obtaining reciprocals of the added results, and setting the obtained reciprocals to the local signal absence probabilities of each of the frequency bands, respectively; and

(a5) multiplying all the local signal absence probabilities to obtain global signal absence probabilities of the specified frame.

3.   The method of claim 2, wherein the generating is performed according to the following equation:

$$\Lambda_k(m) = \frac{p(X_k(m)|H_{1,k})}{p(X_k(m)|H_{0,k})}$$

and wherein,

$$p(X_k(m)|H_{1,k}) = \frac{1}{\pi(\sigma_{S_k}^2(m) + \sigma_{N_k}^2(m))} \exp\left[-\frac{|X_k(m)|^2}{(\sigma_{S_k}^2(m) + \sigma_{N_k}^2(m))} \right]$$

$$p(X_k(m)|H_{0,k}) = \frac{1}{\pi\sigma_{N_k}^2(m)} \exp\left[-\frac{|X_k(m)|^2}{\sigma_{N_k}^2(m)} \right],$$

(Λ k(m) (where k=1,...,L/2)) is the likelihood ratio, L represents the number of points in Fourier transform, $p(X_k(m)|H_{1,k})$ is a probability value of the frequency of the frame according to a local signal presence hypothesis $H_{1,k}$, $p(X_k(m)|H_{0,k})$ is a probability value of the frequency of the frame according to a local signal absence hypothesis $H_{0,k}$, and $p(X_k(m)|H_{1,k})$ and $p(X_k(m)|H_{0,k})$ are calculable using a source signal power $\sigma_{S_k}^2$ and a noise signal power $\sigma_{N_k}^2$, respectively.

4.   The method of claim 2, wherein an *a priori* probability q_k is expressable by the

following equation:

$$q_k = \frac{p(H_{1,k})}{p(H_{0,k})},$$

p(H1,k) is a probability that noise and source signals will coexist at the frequency, and p(H0,k) is

a probability that only noise will exist at the frequency.

5.   The method of claim 2, wherein the specified value is 1.

6.   The method of claim 2, wherein the obtaining reciprocals is performed according

to the following equation:

$$p(H_{0,k}|X_k(m)) = \frac{1}{1 + q_k \Lambda_k(m)}$$

and p(Ho,k|Xk(m)) represents a local signal absence probability for a L/2 frequency of the

frame.

7.   The method of claim 2, wherein the multiplying is performed according to the

following equation:

$$p(H_0|X(m)) = \frac{p(H_0, X(m))}{p(X(m))}$$

$$= \frac{1}{\prod_{k=1}^{M}[1 + q_k \Lambda_k(m)]},$$

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$p(H_{o,k}|X_k(m))$ are the L/2 local signal absence probabilities, and $p(H_0|X(m))$ is the global signal absence probability.

8. The method of claim 1, wherein the estimating a spectrum vector comprises:

(b1) updating a noise signal power for each frequency band of a frame in which it is determined that only a noise signal is included by the global signal absence probability calculated in the calculating;

(b2) estimating an amplitude of a spectral component of each frequency band for one of a frame including both of a source signal and a noise signal, determined by the global signal absence probability calculated in the calculating, and a frame in which the noise signal power is updated in the updating; and

(b3) updating a source signal power for each frequency band using the amplitude of the spectral component of each frequency band estimated in the estimating an amplitude.

9. The method of claim 8, wherein the amplitude of the spectral component of each frequency band is estimated using a minimum mean-square error estimation algorithm.

10. The method of claim 8, wherein the noise signal power $\sigma_{N_k}^2$ is updated according to the following equation:

$$\sigma_{N_k}{}^2(m) = \zeta_{N_k}\sigma_{N_k}^2(m-1) + (1-\zeta_{N_k})|N_k(m)|^2$$

and ζ_{N_k} is a smoothing parameter ($0 \leq \zeta_{N_k} \leq 1$).

11. The method of claim 8, wherein the estimating is performed according to the following equation:

$$\hat{A}_k \approx \frac{\xi_k}{1+\xi_k} R_k ,$$

and wherein

$$\xi_k = \frac{\sigma_{S_k}^2}{\sigma_{N_k}^2} ,$$

$$\gamma_k = \frac{R_k^2}{\sigma_{N_k}^2} - 1 ,$$

and R_k is the short-time spectral magnitude.

12. The method of claim 9, wherein the source signal power $\sigma_{S_k}^2$ is updated according to the following equation

$$\sigma_{S_k}^2 = \left| \hat{A}_k \right|^2 .$$

13. The method of claim 1, wherein the determining comprises:

(c1) comparing the local signal absence probability for each frequency band calculated in the calculating with a first threshold value, and identifying a frequency band in which a signal exists;

(c2) generating the attenuation parameter and the delay parameter from a ratio of the first mixture signal to the second mixture signal for the frequency band identified in the comparing;

(c3) clustering a mixing parameter consisting of the attenuation parameter and the delay parameter generated in the generating; and

(c4) generating the source label vector which consists of a source and a plurality of frequency bands assigned to the source, using a mixing parameter belonging to each cluster clustered in the clustering.

14.   The method of claim 13, wherein clustering the mixing parameter is performed by one of a soft K-means clustering algorithm and a hard K-means clustering algorithm.

15.   The method of claim 13, wherein the comparing is performed for a signal whose signal absence probability is calculated in the calculating, of the first and second sensor mixture signals transformed into frequency domain.

16.   The method of claim 13, wherein the comparing is performed for the first and second mixture signals in which a noise signal is eliminated in the estimating a spectrum vector.

17.   The method of claim 13, wherein the frequency band in which the signal exists satisfies the following equation for an arbitrary source j:

$$\begin{bmatrix} X_{1,k}(m) \\ X_{2,k}(m) \end{bmatrix} \approx \begin{bmatrix} 1 \\ a_j e^{-iwd_j} \end{bmatrix} S_k^{(j)}(m),$$

$\omega = 2\pi k / L$, and L is the number of Fourier transform points.

18.   The method of claim 13, wherein the attenuation and delay parameters are generated by analyzing a ratio of $X_{1,k}(m)$ and $X_{2,k}(m)$.

19.   The method of claim 18, wherein the attenuation and delay parameters are expressable by the following equation in which $\mu^{(k)}$ is a mixing parameter:

$$\mu^{(k)} = (a(k,m), d(k,m))$$

$$= \left(\left| \frac{X_{2,k}(m)}{X_{1,k}(m)} \right|, -\frac{1}{\omega} \angle \frac{X_{2,k}(m)}{X_{1,k}(m)} \right)$$

20.   A computer readable storage medium encoded with processing instructions for causing a processor to perform a method of separating first and second mixture signals received through two sensors into source signals, comprising:

(a) calculating a global signal absence probability for each frame of the mixture signals and a local signal absence probability for each frequency band of a frame for at least one of the first and second mixture signals;

(b) estimating a spectrum vector in which a noise signal is eliminated for each frequency band using the global signal absence probability calculated in the calculating;

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(c) determining a plurality of frequency bands including at least one of a noise signal and a source signal using the local signal absence probability, and generating a source label vector which consists of a plurality of frequency bands assigned to each source, using an attenuation parameter and a delay parameter generated for each of the determined frequency bands; and

(d) multiplying the spectrum vector estimated for each frequency band obtained in the estimating by the source label vector obtained in the determining, and obtaining signals separated according to the source signals.

21.   An apparatus for separating first and second mixture signals received through two sensors into source signals, comprising:

a signal absence probability calculator, which calculates a global signal absence probability for each frame of the mixture signals and a local signal absence probability for each frequency band of a frame for at least one of the first and second mixture signals;

a signal estimation unit, which estimates a spectrum vector for each frequency band in which a noise signal is eliminated using the global signal absence probability calculated by the signal absence probability calculator;

a source signal identification unit, which determines a plurality of frequency bands

including at least one of a noise signal and a source signal using the local signal absence

probability calculated by the signal absence probability calculator, and generates a source label

vector which consists of a plurality of frequency bands assigned to each source signal, using an

attenuation parameter and a delay parameter generated for each of the determined frequency

bands; and

a signal separator, which multiplies the spectrum vector estimated for each frequency

band obtained by the signal estimation unit by the source label vector generated by the source

identification unit, and obtains signals separated according to the source signal.

22. The apparatus of claim 21, wherein the source identification unit clusters a

mixing parameter for each frequency band using a soft K-means clustering algorithm, the mixing

parameter consisting of the attenuation parameter and the delay parameter, and generates the

source label vector which consists of a source and a plurality of frequency bands assigned to

the source, using a mixing parameter belonging to each cluster created to yield a clustered

result.

23. The apparatus of claim 21, wherein the source identification unit clusters a mixing parameter according to the sources using a hard K-mean clustering algorithm, the mixing parameter consisting of the attenuation parameter and the delay parameter, and generates the source label vector which consists of a source signal and a plurality of frequency bands assigned to the source signal, using a mixing parameter belonging to each cluster created to yield a clustered result.

24. The apparatus of claim 21, wherein the signal estimation unit estimates an amplitude for a spectrum of each frequency band, using a minimum mean-square error estimation algorithm.

25. The apparatus of claim 24, wherein the signal estimation unit updates a source signal power per frames, for a frame whose noise signal power is updated and in which only a noise signal exists and for a frame in which a noise signal and a source signal coexist, using the global signal absence probability.

26. The apparatus of claim 21, wherein , when a signal-to-noise ratio of the first and second mixture signals is large, the source signal identification unit calculates the attenuation parameter and the delay parameter using the first and second mixture signals whose noise is eliminated by the signal estimation unit.

27.   A method of separating first and second mixture signals received through two sensors into source signals, comprising:

(a) calculating a global signal absence probability for each frame of the mixture signals and a local signal absence probability for each frequency band of the frame for at least one of the first and second mixture signals;

(b) estimating a spectrum vector in which a noise signal is eliminated for each frequency band using the global signal absence probability calculated in the calculating, and generating first and second mixture signals without noise signals;

(c) performing clustering using the first and second mixture signals without noise, and generating a source label vector consisting of a source and a frequency band assigned to each source; and

(d) multiplying the source label vector obtained by the source identifying by the spectrum vector obtained by the estimating for each frequency band of the frame, and performing an inverse Fourier transform to separate the received signals into source signals of time domain.

28.   A method of separating first and second mixture signals received through two microphones into source signals while eliminating noise from the received mixture signals, comprising:

(a) calculating a global signal absence probability for each frame of the mixture signals and a local signal absence probability for each frequency band of a frame for at least one of the first and second mixture signals;

(b) estimating a spectrum vector in which a noise signal is eliminated for each frequency band using the global signal absence probability calculated in the calculating;

(c) determining a plurality of frequency bands including at least one of a noise signal and a source signal using the local signal absence probability, and generating a source label vector which consists of a plurality of frequency bands assigned to each source, using an attenuation parameter and a delay parameter generated for each of the determined frequency bands; and

(d) multiplying the spectrum vector estimated for each frequency band obtained in the estimating by the source label vector obtained in the determining, and obtaining signals separated according to the source signals.